THE IRON WAYS,

BRIDGES, RAILS & ROLLING STOCK,

CHEAP TRANSIT

COMBINED WITH

STEAM FARMING,

OR,

AGRICULTURE SELF-PROTECTED.

BY A PRACTICIAN.

"He would fain keep a hold on the Actual, knit the New securely to it, and give to them both conjointly a fresh direction."

REPRINTED FROM THE "WESTMINSTER AND FOREIGN QUARTERLY REVIEW" FOR JANUARY, 1850.

LONDON:
PUBLISHED BY G. LUXFORD, WHITEFRIARS STREET.

1850.

Price One Shilling.

LONDON:
PRINTED BY WATERLOW AND SONS, LONDON WALL.

PREFACE.

In reprinting this article from the *Westminster Review*, it seems to us desirable to place briefly before the reader the mechanical, commercial, and moral conditions essential to the prosperity of railways.

Mechanically.

1. That the drainage be efficient, and the substructure firm.

2. That the sleepers, whether of wood, or stone, or metal, should possess sufficient bearing surface to prevent their crushing into the ballast beneath the rolling loads.

3. That the surface-bearing of the rails on the sleepers should be as continued and extended as practicable.

4. That the rails should be of such a section in vertical depth, that the maximum load on them may not induce deflection.

5. That the rails should be of a width proportioned to the loads rolling over them, increasing the breadth as the load increases, on the same principle that a broad wheel is used with a heavy wagon on a highway. And that in case it

be found advantageous to run very heavy engines, the upper surface of the rails should be steeled, to resist abrasion.

6. That the joints of the rails should be so secured as to be immoveable beneath the rolling loads, yet permitting free expansion and contraction, so that there be no deflection, but an equable surface throughout.

7. That on curves the rails should be bent by a machine, so as to prevent the occurrence of tangential lines and sinuosities.

8. That the maximum weight on the wheel tyres of the engines and carriages should be considerably within the limit tending to produce deflection or abrasion of the rails, or crushing of the sleepers or substructure, or the treading out of the tyres. Neglect of this causes enormous waste of steam power.

9. That the construction of the engine should be so arranged as to keep the centre of gravity low, and the base extended, in order to prevent mischievous and dangerous oscillation.

10. That the carriages and the wagons should be made as long and as wide as the curves and the width of the railway will permit, in order to prevent oscillation, and to economise space, material, and labour in working.

11. That each carriage or wagon should maintain steadiness by its length, without trammeling the wheels, which should be free to move laterally, to suit the curves or inequalities of the rails, and avoid friction.

12. That the wheel tyres should be made of dense iron or of steel, so as not to be subject to wear, and that they should be kept as light as may be consistent with strength, in order to diminish centrifugal action. That the section

of the tyres should be such as to permit their application to the wheels by pressure, without heating and cooling, and that the fastenings should not require the piercing of holes through the tread of the tyre, which is a source of great risk. That the wheels should be solid discs of timber or of plate iron, in order at all times to preserve a true circular form, and prevent the fanning action produced by open spokes at high speeds, which helps to waste steam power and retard the train.

13. That the wheels should be free to revolve on the axle, and the axle in the boxes, permitting four movements, thus ensuring the minimum of friction, and diminishing the chance of heating. That the lubrication of the axles in the boxes should be ensured by their revolving in a bath of grease or oil, in constant contact with the lower side.

14. That the springs should be thoroughly flexible and elastic, to prevent all blows or shocks between the carriages and the rails; and that the wheels under each carriage should be sufficiently numerous to prevent any injurious oscillation from acting on a single spring.

15. That the breaks applied to retard the carriages and trains should not so act on the wheels, as to make the wheels sledge or slide on the rails, but that the retarding force necessary to absorb the momentum should be produced by friction between the breaks and the rails directly, thus to prevent the rails from being destroyed at the joints and driven out of the chairs or attachments. Stations should be on elevations, to facilitate starting with little steam pressure, and stopping with little use of the breaks.

16. That every separate carriage and wagon should be provided with traction and buffer springs to prevent snatches and concussions in starting and stopping.

17. That trains ought never to be increased in the number of carriages or wagons, so as to require enormous traction and buffer springs.

18. That the whole of the rolling structures should be as light as may be consistent with strength.

19. That no carriage or wagon should have a greater load on a pair of wheels than is placed on the driving wheels of the engine.

20. That Tank engines of very large size, used without Tenders for fuel and water, should not be permitted, being more mischievous to the road than the Tender engines. The Tender was originally a contrivance to relieve small engines of their weight. To add the weight to engines already too heavy, is a most wasteful contrivance.

Commercially.

1. The more frequent the trains the better the public will be served.

2. Light engines and trains, *i. e.*, small engines and large carriages, can be worked more economically than larger engines and long trains.

3. The same principle applies to light goods, viz., frequent despatches and fast travelling, precisely as the town-carriers now work their traffic.

4. All kind of man-handling of goods wagons is wasteful. Long and large wagons should be drawn by engine power into stations under sheds, with alternate lines of rails and ordinary highways, and discharged by cranes like

canal boats. Short wagons, man-handled, are very expensive railway stock.

5. Short lines in the environs of towns, should be worked by small five minutes' trains, like omnibusses. Passengers do not object to wait for the next train when the trains are in quick succession.

6. That highways may, in many cases, be advantageously laid down with rails for horse transit, on the same gauge, to communicate with branches or main lines of railway.

7. That landowners may, with great advantage, construct cheap lines through their own estates, on which to place their farms.

8. That in many cases it would be for their advantage to *give* the land needful to construct lines of railway.

9. That when the traffic of both goods and passengers is desired in maximum, the true mode is to make two lines for passengers and fast traffic, and a third line for goods and slow traffic, and to provide also a parallel line of highway close to it. The North Woolwich Branch of the Eastern Counties line is a sample of this. Being obliged, by Act of Parliament, to make a parallel highway, the Directors are precluded from charging too high prices, and streets of houses are gradually accumulating. At no great distance of time this line will be a railway through a town on the same level. Future towns will be thus constructed.

For the accommodation of the wealthier classes, willing to pay for speed and accommodation, it would be desirable to institute *Subscription Trains* of great lightness and speed, carrying, say seventy to one hundred first-class passengers, with light luggage, and accommodation for a few servants.

A train of this kind, consisting of an engine and tender

break-van, with accommodation for fourteen servants and luggage, and a light first-class for sixty-four passengers, would cost, as it appears by a document put into our hands, £2,200. It would travel at fifty miles per hour without stopping, and do one hundred miles per day. The total expense for 600 miles per week throughout the year would be less than £1,000, including interest at five per cent. coke, oil, grease, charges, repairs, and depreciation. This is about thirty shillings per train. Take, for example, the Brighton line. There are many gentlemen who would travel backwards and forwards every day if they could do it in two hours, and employ the travelling time in reading or writing. Seventy-eight pounds per annum would be just two shillings and sixpence each journey. Now, supposing each seat numbered, and an ivory ticket, *transferable,* issued, to the taker of the seat, it is probable that in some cases three persons would club to take a ticket amongst them for two days per week each. The profit to the Company by such an arrangement would be enormous.

Total revenue first year, say	£5,000
Total outlay for first year in capital and expenses...	3,200
Profit	£1,800
Revenue second year	5,000
Expenses	1,000
Profit	£4,000

This principle is used in what are called excursion trains, making the transaction a certainty to the company; and there is no doubt that it might be carried on extensively. A company of gentlemen might surely take their

railway carriage on job, as an individual does his private carriage, or as a house is let by the year.

A train of this kind might be run from London to Liverpool, and *vice versâ*, in five hours, starting at 7 A.M. and arriving at noon; starting again at 6 P.M. and arriving at 11, would leave six hours interval in London or Liverpool for business. This, with a carriage fitted for reading and writing, and with not more than five stoppages to water and coke, and without loss of time in ticket collection, would surely be a great advantage to the higher order of the mercantile community.

Supposing the rent of a seat to be £250 per annum for two persons jointly, the annual revenue from 64 would be		£16,000
First cost of two trains, say	£5,000	
First year's expenses, say	4,000	
		9,0 0
Profit		£7,000
Revenue, second year		16,000
Expenses		4,000
Profit		£12,000

Maintenance of way with such light weights would be practically *nil.*

Large roomy seats with folding reading-desks are contemplated in this arrangement. Eight separate bodies to the carriage.

The remaining problem is—are there sixty-four First Class Merchants in London and Liverpool who would set their hands and seals to such an agreement between themselves and the Company? Or if not, how otherwise, and

what annual sum would they give? Fast travelling can be had at a moderate price if the customers can be made permanent.

Morally.

1. That the public should never be regarded as a mere "oyster," or a paying machine, without claims to justice.

2. That the public should be used as a tradesman uses his permanent customers—fairly.

3. That the public should consider the welfare of the shareholder, who ought to have interest for his money.

4. That in the question of alteration of times and prices, faith should ever be kept with the public, and no advantage taken for the purpose of exorbitant gain.

5. That no exorbitant charges should be made, as tending to incite mischievous competition.

THE IRON WAYS,

BRIDGES, RAILS & ROLLING STOCK,

CHEAP TRANSIT, &c.

---

1. *Britannia and Conway Tubular Bridges.* Published with the permission of Robert Stephenson, Civil Engineer. By a Resident Assistant. London: Weale, Holborn.
2. *Britannia and Conway Tubular Bridges.* By William Fairbairn, C.E. Weale, Holborn.
3. *Bow-string Bridges, Blackwall Extension Railway.* Joseph Locke, C.E.
4. *Captain Warren—Triangular-frame Tension Bridges.*
5. *Proceedings of the Institution of Mechanical Engineers.* Robert Stephenson, Esq., C.E., President. October, 1849.
6. *Herapath's Journal, Nov. 24th,* 1849. Article:—"Cannot Railways be worked cheaper?"
7. *Railway Times, Nov. 24th,* 1849. Article:—"Railway Owners and Railway Passengers."
8.—*Mechanics' Magazine.* November 24, 1849. Article:—"Light Load Light Engine System of Railway Transit."

"VIRES acquirit eundo"—gathering strength as it goes—onward marches the railway system, gradually sloughing off the old and effete—the practice-proved defects—and replacing them with newer and more efficient appliances, some of a permanent and some of an ephemeral character, but always progressive. And, in truth, throughout all the arts of life we get very much of the knowledge of what will do, by successive trials of

what will not do. And this truth even Mr. Watt frequently proclaimed of his own mechanical doings, when in the social circle. Of the waste of capital involved in railway making we do not care to speak much, save as a warning for the future. "Gone is gone;" but the real waste has in truth been small. Changing hands has been the chief phenomenon, and though it is pitiable to think that the trust property of the widow and the orphan should pass over to a Hudson—who, after all, was but a mock King of Railways by the aid of juggling financiers—still they were to blame who purchased railway shares for them at absurd premiums. And as for those who took shares in lines with the idea of a firm and safe ten per cent. interest, without labour, and managed by unpaid directors, we can but wonder at the ignorance that imagined such a thing possible while public securities yielded but three-and-a-half, and iron and coal were lying side by side in unlimited quantities, and surplus labourers crying out for employment. It is written that man *shall* earn his living by the sweat of his brow—or of his brain; and although some few jugglers contrive to evade this law, and cheat themselves of happiness while cheating their neighbours of a livelihood, still this cannot be done in the mass. There is no ten per cent. on free capital to be had; it must be worked hard for, or a monopoly of some brain-work must be obtained to procure it as a tribute. Otherwise, why should mankind pay tribute?

"If Cæsar can hide the sun from us with a blanket, or put the moon in his pocket, we will pay him tribute for light; else no more tribute pray you now."

Could railway companies intersect England in the form of a cross, east and west, and north and south, and suffer no one to pass their borders without tribute, even then their ten per cent. would be impracticable, for mechanical art would be at work to circumvent the monopoly, in some new form. The genius of the age runs counter to expensive travelling, and if companies cannot be found to work railways economically for moderate gain, the State will do it sooner or later, when the special knowledge shall be arrived at of the most perfect mechanical arrangements. Meanwhile, the loss by railways has been chiefly the loss of individuals; while, as a national system, the gain has been enormous, yet, withal, but a small fraction of that which is to come, when the true and diversified uses of railways shall be understood.

In the civil engineering of railways, abridging distance between distant points is one main consideration; and the chief works of construction for this purpose are tunnels, viaducts, and bridges, the latter being a technical abbreviation from the verb to *abridge*. Tunnels are a comparatively simple affair, a mere question of time and work. Bridges and viaducts are works of structure, requiring skill and science of the highest kind to achieve perfection therein, bearing in mind two objects, the minimum cost of construction, with the maximum of durability.

Bridges can only be of seven kinds:—1. Arches self-contained, as in the semicircular form. 2. Arches segmental or elliptical, depending on abutments for support. Both these arches depend for support on their power of resisting compression of their particles. 3. Girders self-contained, the upper portion resisting compression with the tension of the lower portion for an abutment. 4. Counter-balanced girders or levers, resting on piers at their centres, in which case the compression is at the lower side, and the tension at the upper. 5. Girders of the lever form firmly fixed upon heavy abutments, with their lightest ends meeting together over the space. 6. Tension bars, tightly stretched between opposite heavy abutments. 7. Catenarian or suspension bridges, consisting of slack chains passing over lofty piers, and sustained by counterbalancing abutments.

All these varieties may be resolved into three, viz., arches depending wholly on compression, chains depending wholly on slack tension, and girders depending equally on tension and compression.

The earliest stone bridges were the semicircular arches, from their evident facility of construction. They are very common in old bridges; but their evident disadvantage, in making a great rise, led to the adoption of the flatter segmental or elliptical arch, depending on abutments, and yielding more water-way with less rise. London and Waterloo are samples of these bridges. For arches of larger span cast-iron was soon found to be the best material, owing to its great rigidity, and the Southwark bridge is a sample of it. But the enormous amount of material required in such bridges caused Telford to turn his attention to the catenarian principle—the cheap light bridge of semi-civilized nations, and he reproduced, in iron chains, the hide and rope and basket-work bridges of Chili, Peru, and Eastern India, to cross the Menai Straits, the pattern of many imitations throughout Europe. The wire bridge succeeded to it; and, if we are not misinformed, it is a wire bridge, on some novel tension principle, over which railway trains now pass the far-famed Falls of Niagara, the tumbling flood of the Erie lake.

The advent of railways, and the multitudinous circumstances with which they had to deal, in crossing over rivers, and under and over canals and roads of all kinds, requiring the minimum of headway, gave rise to the large adoption of the girder bridge, which, in its many ramifications, may almost be considered as *the* railway bridge, *par excellence.* Cast-iron girders, with their lower webs considerably larger than their upper, was the first arrangement for small spans. As knowledge grew, this imperfection was amended by wrought-iron tension rods below. Then came in the wrought-iron girders, the earliest sample of which was the lattice bridge. A bridge of this kind, by Sir John Macneil, the ends being counterbalanced by masses of cast-iron, may be seen spanning the canal on the line from Dublin to Drogheda. This lattice-bridge, depending wholly on uncertain rivets, is the worst form of wrought-iron girder that could be devised.

The next step was the wrought-iron box girder formed of boiler plate riveted together as a rectangular tube. This has been followed up by the hollow tubular girders spanning the Conway and the Menai. In all these girders the principle really involved is that of a roof truss—*i. e.*, the tie-beam or plate below serves as a tension fulcrum for the rigid arch or rafters to abut on. For the essential principle is, that if the girder be parallel top and bottom, it should be of great depth to resist cracking, or that it should be arched to some extent, precisely as the roof, the rafters of which are the most vertical, has the greatest strength of resistance to the vertical load. The bridges of the most important forms may be thus classed:—

1. The tubular bridges of Mr. Robert Stephenson, as exemplified in the Conway and Britannia.
2. The double bridges of cast-iron framework by Mr. Robert Stephenson spanning the Tyne, under the name of the High Level.
3. The Bow-string bridges of Mr. Joseph Locke, spanning the Regent's Canal and Commercial-road on the Blackwall Extension Railway, built by Fox, Henderson, and Co.
4. The triangular frame bridge of Captain Warren, of which samples may be seen on the Guildford and Reigate Railway, and crossing Tooley-street.

The Chester and Holyhead Railway required a bridge *via* the Menai Straits—a piece of salt water subject to the "Droits of the Admiralty." For the passage of heavy trains a strong and rigid bridge was required, and Mr. Stephenson designed one of cast-iron, in two spans of 450 feet each, which we regret was impeded in the execution by the *gaucherie* of the Admiralty; for it would have been a structure of great beauty and of permanent dura-

bility, with little need of repair. Possibly, the Admiralty cared little to have a bridge made at all, upholding water locomotion in preference to land, and sailing vessels to steamers. But anyhow, they pronounced their fiat, without appeal, that no bridge should be erected which did not leave a clear treadway through the whole length, of one hundred feet above high water mark. "And then to breakfast with what appetite you have."

But they had to deal with a clear brain and sound digestion in the person of Robert Stephenson, a man whose breakfast was never disturbed by the apprehension of physicial difficulties in engineering. "Where there's a will there's a way," is an old English proverb, and gladly do we pay our tribute of respect to one who holds the foremost place in the work of ways—of civilizing the world, by the removal of physical obstacles to personal communing between nations. Healthy-bodied and healthy-minded, apt in emergencies, and yet of slow and generally of sound judgment, Robert Stephenson may be regarded as the type and pattern of the onward-moving English race, practical, scientific, energetic, and in the hour of trial, heroic. Born almost in the coal mine, of the racy old blood of the North, with a father strong in mother-wit, stern of purpose, untiring in patience, careful of his small resources—keenly conscious of the bounded sphere his want of early education had kept him in till a later period of life, and determined to pare off from himself all luxuries, all but the merest necessaries, in order that his after-coming should start fair in life with that knowledge he himself held above all price—born thus, Robert Stephenson was emphatically, *well born.* With natural talents, good education, a healthy frame, the rising *prestige* of his father's name—little money, and a large demand for original work in a working and energetic old world, he went forth to the new world, and in the mines of South America and their environs, added new manners and customs to his varied stock of knowledge. More than all this, the genial spirit that ever looked kindly on his fellow-creature, with the intellect that could generally winnow the false from the true, marked him out for a leader of men. Not to his mere mechanical skill does he owe his success in life. That might have been thwarted in five hundred ways by interested rivals; but men wish not to thwart those whom they love; and probably no chief of an army was ever more beloved by his soldiers than Robert Stephenson has been by the noble army of physical workers, who, under his guidance, have wrought at labours of profit, made labours of love by his earnest purpose and strength of brotherhood. We never heard an unkind word spoken of him by his associates, for his is the large nature which grasping at whole subjects, is content

to indicate the details, and leaves them to be wrought out by those in whom he can trust. He is the general, not the corporal of the engineering world; a man of mark, by whom we may the better estimate the petty creatures with inferior natures, whose morbid jealousies will suffer no talent to be developed within their circles, who see nothing new, but with the feeling of envy, and snatch at variations in the minutest details whereon to build a bastard repute, as though a *dilettante* mechanician could constitute a great man. As the world rolls on, more and more will it be understood that, in all ranks of life, the true leader of men must be *generous* of nature, *i.e.*, loving his kind. If he loves only himself, he may be endured for awhile; but the instinct of his fellows will close their hearts to him, and common consent will ultimately throw him down from the pedestal he has unjustly occupied. Even in the army or navy, where despotism is the law, the unpopular chief makes but small progress; how, then, should the leader of civilians thrive, who calculates only on the fear he can inspire?

But to return to our "muttons"—the Admiralty, the sheepish body who follow in old tracks and eschew new ones, their very name a misnomer. Overseers! lookers-on! examiners! Overlookers, indeed, they might be called in one sense, since they cannot see what is palpable to all the world besides. We remember a case in which an inventor submitted to them a child of his brain. In due time he received a letter from the secretary, saying that "My Lords did not think his plan would answer."—"Who are these lords, and what is their capacity for judging?" answered the poor man. He hunted the origin of the opinion till he tracked it downwards to the most imbecile authority that ever twaddled in mechanical engineering.

Such were the men who deemed they had set Robert Stephenson a problem beyond his art, to carry railway trains 450 feet through the air without centres or scaffolds whereon to build his bridge. In answer thereto he said, "Let there be a tunnel formed of boiler plates riveted together—a tube or pipe of sufficient diameter to bear the locomotive with all its load." This conception countersigned by his directors, Mr. Stephenson summoned around him the practical and scientific men, fitted to verify his plan in detail—Mr. Fairbairn, Mr. Clarke, and Mr. Hodgkinson. Mr. Stephenson's first idea was a hollow tube, circular in form. Numerous experiments were tried on this form of tube, but, as might be expected, all were failures, by the tubes collapsing; and this led to other experiments, ending in tubes of an oblong section, with rows of cells of a square form at the top and bottom, to supply the strength to resist tension and

compression. But, after examining the drawings given in Mr. Fairbairn's book, we are of opinion that the cylindrical tubes have not had justice done to them, and that had the same arrangements for stiffening been used, to which the oblong form tubes owe their strength, a very different result would have been obtained. The circular tubes were of thin iron, badly connected. Had they been reinforced internally with edge rings like the internal diaphragms of a bamboo cane; or externally providing also a longitudinal rib, top and bottom, no collapse would have taken place, and we think a better form of tube would have been obtained. So far we think Mr. Stephenson's original conception has not been done justice to. One very serious objection to the top and bottom cells, to the originality of which Mr. Fairbairn lays claim, is the difficulty of continuous examination to guard against the effects of rust, which must sooner or later take place unless they be hermetically sealed, or kept painted, owing to the salt atmosphere. Twenty-eight horizontal flues, twenty inches square and fifteen hundred feet long each, and rough inside with angle iron, are not easy things for an engineer to examine. Had Mr. Stephenson's circular tubes been fairly strengthened, this difficulty would have been avoided, and the external form would have been better adapted to elude the force of the wind. The vertical plates of the square tubes would not maintain their form but for the mass of T iron with which they are ribbed, and had the circular tubes been ribbed, they also would have maintained their form, whether the ribs had been inside or out.

Mr. Fairbairn's book is entitled 'An Account of the Construction of the Britannia and Conway Tubular Bridges.' This is a misnomer. It has nothing to do with the Britannia-bridge in connection with Mr. Fairbairn, beyond the experiments on plate-iron box girders generally. It is the Conway-bridge the elevation of which Mr. Fairbairn describes, and we do not think the title-page or externals of the book indicate this. They mislead people into the notion that Mr. Fairbairn is the engineer and constructor of both these bridges. It is true that some plates are given of portions of the Britannia-bridge, and that Mr. Fairbairn has associated his name jointly with Mr. Stephenson as engineer; and moreover proportions of parts are given; but if we are not misinformed, these are not correct, the original drawings having been altered in the measurements before putting the work in execution.

Mr. Fairbairn states that his object in publishing his work was "the position assumed by Mr. Stephenson, * * * and his endeavour to recognise my services as the labours of an assistant, under his control, and acting under his direction."

We think the position is as follows:—Mr. Stephenson, as general over the work of the whole line, determined the general mechanical arrangements. A portion of these arrangements—viz., the boiler-plate bridge tubes—he, by the consent of his directors, assigned to Mr. Fairbairn, with a salary of £1,250 per annum, to work out practically all the details of the plan. But, in addition to this salary, Mr. Fairbairn was a manufacturer, making his profit on work, labour, and material used in the experiments. Beyond this, he actually had a contract for the bridge work, which, it is said, he sold to another engineer, at a profit of several thousand pounds. If, therefore, Mr. Fairbairn claims to be civil engineer to the company, jointly with Mr. Stephenson, he falls into the anomalous position of being contractor to supply work, and engineer to approve of it and pass it for payment. This would be monstrous indeed, and Mr. Stephenson in admitting such an anomalous position would have laid himself open to a charge of connivance in irregularities. *Utrum horum mavis accipe*—the honour or the profit! We are far from thinking that a manufacturer may not be a competent engineer, and doubtless in no more competent hands could Mr. Stephenson have placed the task of working out the practical results he needed. Apart from all this, had Mr. Fairbairn been ever so much aggrieved, it would have been more delicate to let the world at large appreciate his merits; for, of a verity, each man gets his due reward in his day and generation, and pitiable indeed is the lot of him who has to go about the world proclaiming the injuries he has suffered. We think the whole tone of Mr. Fairbairn's book is too full of that "bare vowel I;" and while recognising in it a certain amount of useful knowledge and information, we rise from its perusal with the conviction that it is a "card of the factory" rather than a "labour of love."

To conclude this part of our remarks, we could wish that Mr. Stephenson's original design of a massive and permanent cast-iron bridge had been carried into effect; and in default of that, his circular tube, properly ribbed, and accessible at all portions to keep in repair and paint, a question which in all wrought-iron structures must be carefully attended to at a great annual expense. But, taking it altogether, it is a giant thought, wrought out in a giant's work as a forerunner of greater things yet to come, a veritable production of a thorough English mind, regarding physical difficulties only as so many dams, against which energy may gather and heap itself up, till it bears down all opposition before it.

Our day dream is—six hours from London to Holyhead—then in an iron-screw steamer double the size of the *Great Britain*, "ruling the waves straight," and bidding sea-sickness avaunt—two

hours to Kingstown—then four hours by rail to Galway, the leaping-off place for the west—then, in another giant steamer, six days to New York—London to New York in a week! What say ye, educators of the people, rulers of the state? With Ireland for a main trunk line and America for a terminus, how long will it be ere one link binds together the hearts of all nations speaking the language of Shakspeare and Milton? Above all things let us have a steamer—a floating bridge that may annihilate the channel between Holyhead and Kingstown. The one thing needed is, great size to ensure swiftness, and stay the vertical heaving of Celtic diaphragms.

Reader! have you ever visited Newcastle, not the Midland town so called, but that on the east coast, where the Tyne runs in the bottom of a precipitous ravine, on the sides of which the town has gradually grown after the strange forms of aggregation peculiar to the older cities, and where a speculator, some years back, with a sudden mania built whole streets of magnificent stone houses for generations to come, many of them meanwhile remaining as carcases occupied by strange inmates? There for ages have horses wrought hard to overcome gravitation in road transit, or rather in hill-climbing; there still the wonder of the stranger is, how the vehicle that bears him is got up the hills, and why it does not overrun the horses in their descent? There have we seen the fire-horse, inanimate, ere breathing the breath of its railway life, emerging from the well known Newcastle factory of the railway chieftain, on a ponderous tumbril drawn by a train of horses as numerous as the foraging border troop of the Percy when he rode to Chevy Chace, winding its slow way over the stone-paved hills to the railway level—on no hostile thoughts intent—not to win wildernesses from wild men, but to win civilization from a wilderness. No battle steed for the hunter of deer or slayer of men, but the courier of commerce, the peacemaker among mankind.

Spanning that ravine at the "High Level," looking down on the old embattled keep and the crooked winding paths where erst travelled the moss-trooper and the hobiler, stands the king of all railway structures, the "High Level Bridge" with its double road, the loftiest for the railway, and beneath that the covered gallery, for the passengers, horse and foot. We know of no more striking object in railway art, combined with utility. The loftiness of the piers, and the lightness of the open cast-iron framings that span them where crossing the river, together with the giant arches over the streets on the southern shore, give to the mind a sensation of wonder when the lulling of the great smoke volcanoes, on a night of clear moon, gives a fair chance of viewing

it. By day, the town viewed from the bridge is magnificent in its murkiness, as the volumes of smoke, changing the sun's rays into all shades of colour, roll by, and the imagination can conceive how beautiful the scene may become when we shall attain the art of making smokeless fires.

In criticising this bridge, one solitary defect strikes us. The engineer faculty has overlaid the artist faculty. The framing of the cast-iron arches should have been made more subservient to the great arch rib, precisely as the main wale of a ship is painted in prominent colours. As it is, the vertical framings from which the lower road appears suspended are far too prominent; and the real fact is, that the arch is a compound girder of open cast-iron work. The structural form is not in conformity with the external appearance. It must, therefore, be considered as a mere pattern, or that the arch is a diagonal brace to the square framings.

Shall we go into the question of commercial result? Perhaps, like the Britannia tube, the cost may be great, but, on the whole, we are glad the two bridges exist. To the public their value is not a matter of doubt. Englishmen can point proudly to their land as the land of railway progress, and we shall consider that the part Mr. Hudson played in forwarding this bridge is something to set off against his numerous *lâches*.

Southward we turn again from the scenes of the old border chivalry, to the marshes where King Alfred turned the course of the Lea river, and left the Danesker ships a-dry; where, also, Maud, or Matilda, the grand-daughter of the Conqueror, being skilless in fording muddy streams, caused the construction of the first stone arch bridge in England, in order to visit Essex unscathed—and there we find an anomalous railway called the Bow Extension of the Blackwall, the history of which is curious. In the year of mania the Blackwall directors awoke from a long slumber, and, getting up, determined to be doing. Of all spots of earth they selected Epping as their Railway Eldorado, from which unheard-of profits were to be made in the transit of sausages and sausage-makers. But the Eastern Counties considered the sausage transit their own peculiar property, and a dire fight was to be waged, and the "tongue fence" of innumerable barristers put in requisition. Then a bright thought struck the belligerents. To stop short at Stratford was made the compromise, and so the act was obtained. But the hard ground extended only to Bow, and the scene of King Alfred's military engineering affrighted them with the expense. They had before them the bridging of the Lea and all its creeks and tributaries, with the embankments and culverts in fearful array on the

Eastern Counties line. It was therefore resolved to stop short at Bow.

In the nursery rhyme Jack Jingle's iron failed as a horseshoe first, and then as a nail. But he magnanimously resolved to make a sensation, so, heating the iron hot, he plunged it into water—

> "'Hiss!' quoth the iron.
> 'I thought so,' says Jack!"

Even so, the thirty-five miles to Epping dwindled to three-and-a-half miles to Stratford, and then again to a mile and three-quarters from Stepney to Bow, carried on brick arches, with several costly bridges, at an expense of £250,000.

> "'Hiss!' quoth the shareholder.
> 'I thought so,' says bystander."

But that was not all. When the "line" was ready for opening, after a long incubation of engineers, surveyors, and solicitors, notice was given to the Eastern Counties to effect a junction with their rails. "We do not need any junction," said the wise men of the east. "But you must, by Act of Parliament," retorted the sages of Fenchurch-street. "Cannot find it in the bond," rejoined the eastern magi. "'To make a railway from Stepney to Stratford,' says the deed. And, moreover, where are our trains to go to at Fenchurch-street, a *cul-de-sac*, where, if we once get in, there will be no emerging? Widen your line first." And so the line remained—the Stepney No-Junction.

The question was once put to us, "For whose benefit are railways made?" The asker was a shareholder, disappointed of a dividend. We began to enumerate. For parliamentary agents, for barristers, for solicitors, for surveyors and architects, for engineers, contractors, and—here we stopped short, considering that the shortest mode would be to state for whose benefit they were *not* made, viz., the shareholders.

The Blackwall is a line which ought never to have been constructed, excepting as a dock and city terminus for the Northern railways. Its new Stepney extension should have been planned in connection with the extension of the Birmingham from Camden-town to the West India Docks. A large expenditure must now be incurred to adapt it to this object. Sooner or later, however, this difficulty must be met; and the directors of the London and North-Western Company would do well to consider it, while the shares of the Blackwall are to be obtained for an old song, and before any further capital is wasted in designs without comprehensiveness. The junction they are now effect-

ing with the West India Docks, will be incomplete without an extension to the London and St. Katherine's Docks, and without a quick communication with the city. The London and North-Western Company should not only purchase the Blackwall, but should extend it to King William-street; that is to the open space made by the intersection of the three principal city thoroughfares.* A terminus there would not only command the short traffic of Hackney, Clapton, &c., but a very large portion of the through traffic, for which omnibuses are now employed between the city and the Euston-square station.

But even the present waste has borne one fruit of public utility, in a new form of bridge, as some compensation for the money thrown away upon loop-holey Acts of Parliament, and buyings and sellings, and takings and givings up, of houses and lands and other property.

The bridges of the Stepney extension are hollow iron box girders, made of boiler plates riveted together similarly to the Britannia and Conway. But they are not straight girders. The boxes are about 18 inches square in section, and they are constructed in a curved form, like a large bow, of the same sectional size throughout. To prevent this arch from flattening when the load is on it, the ends are made to abut on horizontal tie-rods of proportional strength. On those tie-rods the road is carried, vertical rods being attached between the tie-rod and the bow, as in an ordinary suspension bridge, and diagonal braces are fixed so as to prevent oscillation. Thus the suspension being effected from a rigid arch, instead of a loose chain, a bridge is produced sufficiently rigid for railway trains, together with great lightness. What we have described is the structure of a bridge rib—two such ribs constituting the bridge to carry two lines of rails. The principle, in fact, is that of a roof-truss in an arched form, combining the principles of compression in the upper portion, and tension in the lower, as in an ordinary girder. The bridge which is erected over the Regent's Canal has a span of 117 feet. It is 27 feet wide, and the versed sine from rib to tie-bar is eight feet. The total weight is 194 tons. These girders have been proved to a weight of two tons per foot run. As regards the power of resistance in the arch, we see no difficulty in carrying that to any

* The length of an extension from Fenchurch-street to King William-street, would be about the third of a mile, and if laid out on the principle of a railway arcade, the ground required to be purchased might be made so productive as to reduce the expense to an insignificant sum. By a railway arcade, we mean a well lighted passage with shops or counting houses on each side. The rails to be carried by the roofs of the shops, upon the plan of a design by Mr. Fowler, which appeared in the 'Westminister Review' for June 1846.

amount, by making such ribs lie vertically one on the top of the other, precisely as the Americans make timber arches of planks laid one on the other, like brickwork rings of our railway bridges. But for great spans, we see a difficulty. It would scarcely be possible to maintain steadiness vertically, without connecting the ribs together by tie-bars at the top, boxing them as it were together, and perhaps increasing the width of the roadway. Beyond this, there still remains the difficulty as to how long such box girders will last. If they now be hermetically sealed, so that wet cannot penetrate the interior, we should entertain little doubt; but it is probable that, in future constructions, the plates will be effectually galvanized, to render them very durable.

We have no doubt that ultimately the Blackwall will be used as one of the principal termini of the Northern and Eastern lines, and that Shoreditch will be principally devoted to the objects of a goods' station; but before this takes place, men of business and purpose must occupy the seat too long usurped by inefficiency. Meanwhile, the best thing a new Board could do, would be to run five-minutes small trains on the main line from Blackwall to Fenchurch-street; making it literally an omnibus line. Only thus can they compete with the men whose naturally keen wits are sharpened by horse-dealing.

The last kind of bridge we have to notice is that of Captain Warren, erected over the Guildford and Reigate Junction, and also in Tooley-street, by the engineer of the South-Eastern Railway Company. The principle of this bridge is a horizontal tension-bar or chain, which is rendered stiff by the application thereon of a number of triangular frames of cast iron. The lower points are attached to the tension-rod, and the upper ones abut together in a parallel line with the lower rod. By inserting small wedges between the abutting ends of the triangles, any amount of camber may be given to the bridge after erection, to compensate for irregularities or extra load, so as to preserve the horizontal level, or make the centre rise. It is evident that, as in an ordinary suspension chain, the whole strength of this bridge depends on the tension-rods or chains—the end pressure of the angular frames merely serves to give horizontal stability and abutment. The bridge may be regarded as an ordinary girder, formed of open work, removing the portions near the neutral axes which yield little strength.

Having thus far "bridged" our way, we now turn to the consideration of the "Way" itself, and the uses to which it is mechanically applied. Years ago we called public attention to this subject, both in these pages and in those of the railway press; but, at the time, our remarks received scarcely any attention, for

railways were in their hey-day, and sundry not very sound maxims were received as orthodox, such as weight is no object on railways—weight is speed—wear and tear is practically *nil*—rails will last thirty years—rolling stock an indefinite period—and so on. The errors since persisted in were not wholly without warning. A voice was lifted up against them, unregarded amidst the din of cupidity, that defeated its own proposed object—gain.

But *truth* will find its way. Rails have been destroyed, and rolling stock has been resolved into its original elements, and amidst this "wreck of matter" many human beings have been prematurely cut off, whose deaths are clearly traceable, in most instances, to disproportion of materials, as clearly as that deep ships will ground in shallow water, or eggs break under cart-wheels, or ice melt at 40° of thermometrical heat above zero.

We will now endeavour to arrive, as nearly as possible, at

THE RATIONALE OF ECONOMICAL TRACTION ON RAILWAYS.

The general principles that should govern the construction of railways in nowise differ from those of highways. They are both *roads* to bear rolling wheels, composed of a wearing surface and a substructure; in one case a surface of stone over the whole substructure, for the wheels to travel over all parts; in the other case, a narrow surface of iron fixed to timber or stone blocks forming the substructure, the wheels being trammelled to run on the iron surface.

On the highway the strength of the surface and substructure is usually estimated by the load which horses are capable of drawing; but to prevent the crushing of the surface, the wheels are increased in breadth in proportion to the load; and to produce voluntary compliance with this essential condition, the tolls on highways are lessened in proportion to the increased breadth of the tyres or tread on the road. There are, of course, limits to this, and the usual practical limit is what four horses can draw. Even with that limited weight, it was found that the abrading surface beneath the wheels and the horses' feet was so serious an evil, by producing increased resistance, that hard iron rails with a narrow surface were substituted for the broad surface of yielding stone, and thus grew up the railway system.

But iron is not indefinitely hard, or substructure indefinitely durable; and these two facts were thoroughly appreciated by the directors of the Liverpool and Manchester Railway when, in offering a premium for the best locomotive engine, they specified the maximum weight to be under five tons.

But they did not at the same time specify a maximum of speed, because, at that time, speed was not imagined. Even passengers were not imagined.

Running trains commenced, and passengers increased; carriage after carriage was added, for steam did not break its wind, did not die on the spot, as horses would have done. The result was, a lessened speed from increased load. But speed must be had at any cost, and the power and weight of the engines were increased. Again more carriages were added, and again were the engines increased. Then began the struggle for speed between the broad and the narrow gauge, till the rails and substructure gave way, and shareholders awakened to the conviction, that in six years they had worn out the fixed plant that was to have lasted thirty, and had also worn out—their dividends.

There is no doubt that speed is a useful thing, if it can be attained without too high a cost; and there is little doubt that speed may be maintained without excessive cost. But, to accomplish this, the managers of railways must take example from the practice of the highways. There the fast coach was the light coach—heavy conveyances travelled slowly. On railways this practice has been reversed. The heavier the engine the faster the speed—as though weight and speed were synonymous, and not the contrary. The whole present system is confined in a vicious circle, from which there is no escape but by remodelling.

The rate of travelling must in all cases be more costly as excess of speed is attained; but we must not lose sight of the fact, that a light well-constructed train, with a specific number of passengers, can travel at forty miles per hour at less cost than a heavy badly-constructed train at twenty. And an engine of ten tons weight can attain as great speed as the largest engine that ever was constructed, and in most cases greater speed, precisely as the light Arab horse can outstrip the elephant, whose feet sink into the ground—precisely as rails sink beneath the tread of our monster engines.

To obtain the maximum of result on railways, it is essential, before all things, to ascertain the proportion of weight on the wheels of the rolling stock that the rails and substructure can sustain at the maximum speed, without crushing; for, the heavier the load, the less in proportion must be the speed. It is quite true that the greater the speed the less is the vertical weight while running, but so much greater is the impinging force laterally and longitudinally, and proportionably greater will be the amount of destruction.

It must be evident that all surplus weight in rolling stock is an unnecessary evil, carrying about lumber without profit; and

the longer and heavier the train, the greater is the proportionate weight. The mere arrangement of springs to provide against longitudinal concussion amounts to half a ton per vehicle. The enormous disproportion of dead weight to load that has obtained on railways may be gathered from the facts, that the light stage-coach weighed seventeen cwt. and carried nineteen persons, including guard and driver, while the first-class carriage on a railway weighs four tons and carries eighteen passengers only. The risk of longitudinal collision caused by long heavy trains is the reason of this disproportion.

This surplus weight involves another difficulty. To start a train into motion requires many times the power needed to keep up speed when once attained, supposing the road to be level, and in good order. To check the momentum thus acquired, in case of an impending collision, or when stopping at a station, requires a corresponding amount of power, by using breaks, or by reversing the steam. All this is positive waste, and the more frequent the stoppings the greater must be the amount of waste.

There are two ways of considering the question of traction; mechanically and commercially. A thing may be mechanically practical which is commercially unadvisable.

Mechanically. First, the rails should be so hard as to resist abrasion on the surface in contact with the wheels; and so stiff, vertically and laterally, as to be incapable of deflection by weight or concussion of the passing load. And, moreover, the joints should be so formed that the rails at their abutment should be as free from deflection as at any portion of their mid-length, precisely as a fishing-rod is as strong at the ferule-joint as at any other portion.

Secondly. The substructure should be so firm, that no amount of rolling load can displace the sleepers, or crush them down so as to require "maintenance of way."

On scarcely any line of railway are these mechanical conditions to be found. The rails are abraded and crushed out on their surfaces; they are hammered into notches in their chairs, and are loose therein; and their abutting joints are not of one-fourth the strength to resist deflection that exists in their intermediate portions. The clinking, clattering sound familiar to the ear of every traveller, like the loose shoe of a horse, is caused by the springing of the rails in the joint-chairs at every fifteen feet distance, and not only destruction thence arises, but retardation of the train. The momentum is momently absorbed by concussion, and fresh steam must be generated to replace it: it is equivalent to starting the train afresh.

It is evident, therefore, that the weight of the rolling stock is

in excess of the railway strength. Mr. Stephenson warned the legislature of this three years back. "If you persist in the use of heavy engines, you must reconstruct your railways." The engine tyres are many times the strength of the rails they run on.

There are two mechanical modes of meeting the difficulty. One is, to increase the strength and weight of the rails and railway; the other, to diminish the weight of the rolling stock.

Against the former—increasing the weight of the rails, Mr. Brunel, who should be skilful in questions of weight, has lifted up his voice in the Institute of Civil Engineers, proclaiming that, in his practice, rails of 60 lbs. to the yard are more durable than those of 85. He says, that no good iron can be obtained in large sizes. Very possible, though that difficulty will not long endure under incessant competition, skill, and industry. The more probable solution is, that the light rail is elastic, and gives and takes better with the longitudinal sleeper to which it is fastened. And it is quite clear that the elastic yielding will have a tendency to elude abrasion. But this will be at the cost of wasted steam-power, precisely as a horse, in galloping over loose sand, will save the waste and wear of his shoes at a much greater expenditure of wind.

The present rails of the heaviest make are 92 lbs. to the yard, and practical instances exist of their being actually trodden out in nine months by existing traffic. Therefore, to get a durable rail, the weight would require to be at least doubled, and the surface artificially hardened with steel, to resist abrasion. There is yet more than this. The contact of the wheel with the rail is a point, or, at most, a line across the rail. The width of the present rails is two inches and a half. To get sufficient surface to prevent crushing, would require probably five inches breadth; and, to produce this, would require iron of at least 300 lbs. per yard.

To support such rails proportionably, would require a range of cross sleepers in close contact with each other, similar to the "corduroy" roads of America.

This would be costly in capital, but supposing the traffic in proportion, warranting the incessant use of monster engines—a stream of passengers and goods not otherwise to be carried—it might be an advisable investment. The use of the monster engines *without* the giant's road, can clearly only be ruinous.

But if, on examination, it appears that the amount of traffic could be carried over the same rails by merely duplicating or tripling the number of the trains, and thus reducing the weight, it would be commercially the best arrangement. And supposing

the traffic still to increase, it would be better to duplicate the number of the rails than to duplicate their strength.

In dealing with vessels in water, increase of size is of little disadvantage compared with the advantage, because increase of size gives increase of surface-bearing. But the tread of a wheel on a rail can be very limitedly increased, and only by the breadth of the rail. Practically, the bearing surface is commonly a point.

To determine the weight that may be advantageously placed on a single wheel, we must revert to the power of iron to resist crushing. From mechanical experiments, it appears that good wrought iron begins to crush under a steady weight of eleven tons to the square inch. Now, the driving wheels of many locomotive engines have ten to eleven tons on a surface of two points. It is evident, therefore, that destructive wear must ensue. Engines of eleven tons weight on two points, at forty miles per hour, over unsteady rails, may very well warrant the appellation of *anti-dividenders.* If, therefore, the weight on a pair of driving wheels can be reduced to five tons, the resisting power upon the rails may be in excess of the crushing power of the load, and the way be rendered really "permanent," *i. e.*, permanent in durability and not in expense of maintenance. It is obvious that this is mechanically the most economical arrangement, if the mechanical power be competent to the commercial demand. Upon examination, we shall find that, in ordinary traffic, a large portion of the engine power is at present absorbed in carrying dead weight. An engine, a tender, a break-van, one first-class, and three second-class carriages, make up a gross weight of 55 tons on 30 wheels, and afford accommodation for 18 first-class and 96 second-class passengers—total 114.

Net weight of passengers, say..	.. .. tons	9
Ditto train	.. .. ..	55

or more than six tons dead weight to one ton of paying load.

But on the Eastern Counties and the Cork and Bandon lines it has been shown, that with a differently constructed engine and carriage, weighing only 21 tons, on 16 wheels, 20 first-class, and 96 second-class—total 116, may be conveyed at the same speed, and with a consumption of only one-third as much coke. In this case, the proportions will be

Net weight of passengers, say..	.. .. tons	9
Ditto train	.. .. ..	21

or little more than two tons dead weight to one ton of paying load. The advantages, therefore, in favour of the light system, are—

In non-paying weight, as..	21	to	55
In passengers	116	„	114
In wheels..	16	„	30
In coke	1	„	3
In oil and grease	1	„	3
In outlay of capital	1	„	2
Interest on ditto	1	„	2
Repairs	1	„	2
Depreciation	1	„	2
Maintenance of way	0	„	0

In answer to this statement, it may be objected that the large engine has the capacity to take more carriages if required. But the light engine could take another carriage if required, or a horse-box or carriage-truck, as the boiler is far more powerful in proportion to size. But in this sort of indefinite calculation lies the great error committed by railway companies. They assume the largest possible, instead of the largest average, maximum. The true plan is to provide for the maximum average, and let the occasional surplus wait till the next time, as was the case with the stage-coaches. A maximum average of 100, might on an occasion reach 1000, but it would be absurd to provide a train for them. The stage-coach proprietors put on a special for the emergency, and so should the railway proprietors. The expense may be objected to; but, in the first place, the expense should not be incurred without a remunerating number of passengers; and supposing the number sufficient, the only extra expense between two trains and one, other things being equal, are the wages of driver and stoker. But if a proprietor of an omnibus, with a maximum of 25 passengers, can afford a driver and conductor, surely it cannot be important with a maximum of 110.

Supposing that two small trains could be worked at the same cost as one large one, it is manifest that a greater profit would ensue by the increase of passengers, through better accommodation to the public.

In practice on one of the most important metropolitan lines, the largest number of passengers in one train at one time, during twelve months, on the main line, was 230, and the average maximum 118. On the branches, the average maximum was 116. With light trains it would be practicable to run every quarter of an hour, as the risk of collision is very small; and special trains, with the expense so much reduced, would become more frequent. For branch lines, still smaller engines would suffice; and it is probable that it might be arranged for the guard to take the fares from passengers, without needing stations or clerks. In such

case the existing stations might be let for refreshment-rooms, or for other purposes, at a profit rather than an expense to the companies.

If the various companies would adopt the practice of making up lists of the passengers entering and leaving the trains at every station, the numbers might be ascertained and accommodation provided accordingly. Supposing a train to consist of three first-class carriages, with 54 passengers, and nine second-class with 288—total 342, and that it was entirely full, the proportion of dead load to living would be 87 to 26. But nothing like this is the fact; for on one of the largest metropolitan lines, during the year 1847, the proportion of dead load to living was 26 to 1.

The light system contemplates a different arrangement of seats from those in common use. It has been stated that passengers prefer arm-chairs in the ordinary fashion. Very probable: but if it be explained that the shareholders cannot afford to carry so much dead weight without extra fare, and that the carriages would be supplied accordingly, all objections would soon cease. There are several mechanical questions to consider besides the mere lightening of the trains. The joints of the rails require to be made perfect, and the rails require better securing. Wheels and axles are yet far from having attained their true form, the whole system of breaks is a mechanical abortion, and springs are very imperfect. Twenty years have not sufficed to accomplish in railway plant what it took fifty years to accomplish in stage-coaches—the fixing a standard form. Yet it must be done before profits can be calculated on.

In making future railways—which will again be rife so soon as the final extent of wasted capital in the existing lines is understood—the light system must come largely into operation. The saving of cost in construction of bridges and works for light weights will be very great; and if landholders come to their senses, as they will be fain to do, the probability is that railways will be made, with rolling stock complete for passengers, at about £7,000 per mile of double way. The existing railways must look to it, and set their houses in order. They must write off their wasted capital, and make the most of their goodwill, being the first in the field. There is no improbability in the assumption that Telford's Menai Bridge will yet serve for the transit of light railway trains in the coming time, when Ireland shall be an integral part of England, and the Holyhead sea-ferry be worked by the longest iron steam-ships the world can boast, setting fire, wreck, and sea-sickness alike at defiance—practically a moving steam-bridge, as simple as the present passage of the Mersey

from Liverpool to Birkenhead, and scarcely more costly to the passengers.

Again are the shareholders warned of their position, and that there are two modes by which they may obtain dividends. First, by reducing their working expenses as pointed out; and secondly, by encouraging their traffic. The public should be encouraged to build houses, and locate farms, and erect factories close to the lines, and this can only be by the companies guaranteeing them low prices, and frequent trains secure against changes. When this shall be done—when the public and the shareholders shall cease to be at variance, railways will have a tendency to grow up into streets of a value greater than the most sanguine imaginations have yet calculated on.*

Meanwhile, signs of the coming times may be perceived. Sir John M'Neil, in Ireland, after making high-priced lines, is now patenting "light locomotives and cheap railways." And in England also, various original improvements are now practising after the originators have expended time, and money, and industrial energy in calling public attention thereto. Some are stimulated by the desire of direct money gain, others by the wish to steal a repute that may bring money indirectly; and, as usual, those who sought to guide the public aright, when profits were only to be made by gulling it, are left to thrive as they can, perchance to hunt down a new quarry for the vultures again to pounce on, so soon as the hunter has clutched it. Well; this, too, is an ordinance of providence.

In confirmation of what we have written, we now extract from

---

* This would be especially the case on the Brighton line; but the original Board, instead of promoting the object, dug the fields near their stations into holes for bricks, leaving the holes as swamps, and totally destroying, in several instances, the beauty as well as salubrity of a neighbourhood. We regret to observe that these swamps along the line are still neither filled up, nor their sides planted; and, also, to learn that complaints are continually made by local residents, of the want of accommodation in the arrangement of trains. It appears that out of only twelve stations between London and Brighton, there are five at which the trains stop only mornings and evenings, with intervals of nine hours between them. We need hardly add our opinion to that of the Editor of the *Railway Record*, that no building along the line, or improvement of local traffic, can be expected under such heavy discouragement. The reason that would be assigned by the directors, is doubtless the expense of frequently stopping heavy trains for an inconsiderable number of passengers; and inconsiderable they must of course always be in the first instance; for where villages grow into towns, they do not do so in a moment. This is an additional argument in favour of light engines and light carriages, which admit of greater frequency of despatch, without a corresponding expense; not a reason for checking the development of traffic; which will most assuredly never realize the expectations of shareholders, unless a change of system be adopted.

the proceedings of the Institution of Mechanical Engineers at Birmingham, in October, the substance of a paper read before them by the engineer of the Eastern Counties line:—

ON THE ECONOMY OF RAILWAY TRANSIT.

"The object of the present paper is to show that the locomotives now in use on most of the railways have outgrown the wants of the passenger traffic, and that the weight on the driving wheels of these locomotives, amounting in some cases to 14 tons, is perfectly unnecessary for the number of passengers conveyed in 99 cases out of 100.

"For the purpose of obtaining practical data upon this subject, the writer of the present paper procured a return of the number of passengers conveyed on the Eastern Counties and Norfolk Railways, both main line and branches, by each train during the week ending 7th May, 1849; this return showing the greatest number of passengers in each train at any one time.

"It appears from this return that the greatest number of passengers in any main line train at any one time was 231, and the least number 7; the greatest number in any of the branch line trains being 82, and the least number 3.

"And by another return from the books of the company it appears that there were conveyed on the Eastern Counties' branch lines during the year 1847, 42,644 tons of passengers (calculating each passenger with his luggage at 168 lbs.), and that the weight of engines and carriages required to convey them was about 1,112,500 tons, being in the proportion of 26 to 1.

"On examining the coke returns it also appears that the main line engines consumed from 24¼ to 40½ lbs. per mile, and the engines for working the branch line trains consumed from 16½ to 35½ lbs. per mile, varying of course with the size of the engine employed to do the work, the smallest engines invariably consuming the smallest quantity of fuel for the same work done. The average consumption of coke during the half-year ending 4th July, 1849, was 31½ lbs. per mile for passenger engines, and 47¾ lbs. per mile for goods engines.

"These returns refer to a stock of about 200 engines, and a length of line of about 310 miles.

"Thus the writer came to the conclusion that it would be possible to construct a carriage and engine combined, of sufficient capacity for branch traffic, and by his advice the directors of the Eastern Counties Railway gave orders to Mr. Adams to construct such a carriage, subject to the approval of Mr. Hunter, the locomotive superintendent.

"The carriage was accordingly built, and called the 'Enfield,' from the branch which she was intended to work.

"The diagram shows the 'Enfield.' The engine has 8-inch cylinders and 12-inch stroke; driving wheels 5 feet diameter; distance between centres 20 feet; width of framing 8 feet 6 inches. The boiler is of the ordinary locomotive construction, 5 feet long by 2 feet

6 inches diameter. The fire-box is 2 feet $10\frac{1}{2}$ inches by 2 feet 6 inches.

"There are 115 tubes of $1\frac{1}{2}$ inch diameter and 5 feet 3 inches in length, giving a total of 230 feet heating surface in the tubes. The area of the fire-box is 25 feet, giving a total heating surface of 255 feet.

"The weight of this steam carriage is 15 tons 7 cwt. in working trim. The engine and carriage being combined, it is evident that the weight on the driving wheels is increased by the load carried, and that this weight increases in the same ratio as the load required to be taken.

"The extreme distance between the centres of the leading and trailing wheels being 20 feet, accounts for the steadiness of this machine; there is indeed no perceptible oscillation when travelling at the highest speed, and this verifies the observation 'that the steadiness of an engine depends not on the position of the driving wheel, but upon the length of the rectangle covered by the wheels.' This engine at the same time daily traverses curves of 5 or 6 chains radius.

"The 'Enfield' steam carriage was originally intended to convey 84 passengers; but as it was found that when she was put on as an express train the passengers increased in number, a 'North Woolwich' carriage was attached capable of conveying 116 passengers, and also a guard's break van, making provision altogether for 150 passengers, which is now her regular train taken at a speed of 37 miles per hour.

"This engine commenced her regular work about eight months since, and the following return shows the miles run and coke consumed by this engine during the $7\frac{1}{2}$ months regular working from January 29th to September 9th, 1849.

14,021	total miles run.		
705	hours, running time.		
1,457	ditto, standing time.		
2,162	total hours, in steam.		
743	cwt. coke consumed in running.		
408	cwt.	ditto	standing.
286	cwt.	ditto	getting up steam.
1,437	cwt. total coke consumed.		
11·48	lbs. per mile average consumption of coke.		

"The 'Enfield' is in steam 15 hours per day, the fire being lighted about six in the morning and drawn at ten o'clock at night. But of these 15 hours it appears by the return that she is engaged running only 5 hours, the remaining 10 being employed standing in the siding.

It was found by experiment that the quantity of coke consumed standing was 32 lbs. per hour, and after deducting this and the quantity consumed getting up steam, it will appear that the actual consumption of coke running is under 6 lbs. per mile.

"It must also be particularly borne in mind that this consumption of coke includes the total goods and coal traffic on the branch, amounting to 1,410 tons; viz., 169 tons of goods and 1,241 tons of coal.

"The 'Enfield' steam carriage worked the 10 a.m. passenger train from London to Ely on 14th June, a distance of 72 miles, taking behind her three of the ordinary carriages and two horse-boxes: she arrived at Ely eight minutes before time, and the total consumption of fuel, including the getting up steam, was found to be 8¾ lbs. per mile. The tubes of the boiler are only 5 feet 3 inches in length, and the economy of fuel is consequently scarcely at the maximum.

"Another engine on a similar plan to couple with a 40-feet carriage is now nearly ready, the tubes being 6 feet 6 inches long, from which is expected even more economical results.

"The result of the writer's experience is the conviction, that for express purposes, and for the larger portion of the branch traffic on railways, the light steam carriage is the best adapted and most economical machine, both as to first cost compared to the work done, and in working expenses.

"The repairs of the permanent way are also very much reduced, as may be easily imagined.

"On the Eastern Counties' Railway an engine and tender of say 30 tons, a break van, a first-class carriage, and three third-class carriages, conveying say 120 passengers, make a total weight of 59 tons, and the consumption of coke, as has already been shown, is on the average 34 lbs. per mile. A steam carriage weighing only 17 tons will transport the same number of passengers at from 7 to 8 lbs. of coke per mile when the best proportions are attained."

Before and since that time the railway press has taken up the question with earnestness. The edition of 'Herapath's Journal' of November 24th, has an article entitled "Cannot Railways be worked cheaper?" and gives the particulars of the "Cambridge" engine, which was supplied to the Eastern Counties directors at a later period than the "Enfield." We extract from the journal:—

"Speaking of the Eastern Counties' Company, what are they doing? The iron hand of necessity has compelled them to look to their expenses of working. The heads of the new parties who have come into the management are being directed most earnestly and hopefully to a reform in the working expenses. They are seeing what can be done in the way of economy by lighter locomotives. They have invited ingenuity to their aid, and the result at present obtained

is the production of a new light engine, called the 'Cambridge,' of which we have collected the following facts.

"THE 'CAMBRIDGE.'

"The ordinary train consists of—	Weight. Tons.	cwt.	qr.	lb.
The 'Cambridge' engine, with 3 cwt. coke and 230 gallons water .... (cost £1,200)	9	11	3	8
One 8-wheel carriage, as on the North Woolwich line, with tank underneath full of water (cost £600)	11	10	0	0
One 6-wheel first-class carriage ...... (cost £400)	5	10	0	0
One 4-wheel break van.................. (cost £250)	3	15	0	0
Total weight ready for the road	30	6	3	8

"The present accommodation is—	First Class.	Second Class.
In the North Woolwich carriage	40	76
In the 6-wheel first-class ditto	24	0
Total..............................	64	76=140

But the train being for first-class only, the second-class compartment is not used, the number conveyed at present, therefore, is 64. A North Woolwich carriage is now being fitted up for first-class, and will hold 80 when altered, giving better accommodation and more space than in the present ordinary first-class carriages. When this is finished, it will be unnecessary to run the 6-wheel first-class carriage, which will reduce the weight of the train to 24 tons 17 cwt. The consumption of coke, which is at present 10·25 lbs. per mile, would be reduced to about 9·50 lbs.

"The cost of working the train is as follows:—

Total cost (see above) £2,450.

	£	s.	d.
Interest on capital at 5 per cent.	122	10	0
Depreciation, ¾d. per mile on 20,000 miles	62	10	0
Ordinary repairs, 1½d. ditto	125	0	0
Coke, 20,000 miles at 10·25 lbs. per mile = 92 tons, at 23s.	105	16	0
Wages, 6 days per week, at 11s. 6d.	172	10	0
Oil, tallow, waste, &c..	10	4	0
Total cost per annum..........................	£598	10	0

for 20,000 miles = 7·18d. per mile.

"The cost of working this train with the new first-class North Woolwich carriage (doing away with the 6-wheel carriage), will be as follows:—

Total cost £2,050.

	£	s.	d.
Interest on capital, at 5 per cent.	102	10	0
Depreciation, ¾d. per mile, for 20,000 miles	62	10	0
Ordinary repairs, 1½d. ditto	125	0	0
Coke, 20,000 miles at 9·50 lbs. per mile=85 tons, at 23s.	97	15	0
Wages, 6 days per week, at 11s. 6d.	172	10	0
Oil, tallow, waste, &c..	10	5	0
Total cost	£570	10	0

for 20,000 miles = 6·84d. per mile.

"In the expense of 7.18d. per mile is included an item of considerable amount for interest at 5 per cent. on the capital cost of the train. Mr. Cabry says, the York and North Midland trains are run for 9½*d.* per mile; but in that expense there is not the charge of *interest* on the capital cost of the trains, which must be heavy, and coke on the York and North Midland is had for 11s. 6d., while on the Eastern Counties the price of it is 23s., or just double.

"It is calculated, as already mentioned, that by taking off the 6-wheel carriage this light train can be run for 6·84d. per mile, including interest on capital cost of the train.

"Beyond the advantage of a most considerable saving in the expense of running trains, light engines will not knock about the rails so much. The whole train of the 'Cambridge' is not so heavy as some of our ponderous engines; the engine of the 'Cambridge' is about a third of the weight of those great machines.

"The 'Cambridge' generally performs the distance between London and Norwich (126 miles) in about four hours, that is, a speed of 30 miles an hour.

"*The following are particulars of a Trip on Thursday, Nov. 1, 1849, with 'Cambridge' Engine and Train, from Norwich to London.*

Distance from Station to Station.	——	Time of arrival.	Time of Departure.	Time occupied running.	Speed between Stations.
Miles.		H. M. S.	H. M. S.	M. S.	
	Norwich..........	..	10 30 0	..	(*a*)
¾	Prowse-bridge	..	10 32 30	2 30	18
¼	Ditto station....	..	10 34 30	2 0	3.75
5½	Hethersett........	..	10 46 30	12 0	27·50
4	Wymondham......	10 51 30	10 55 0	5 0	48 (*b*)
2½	Spooner-row	..	11 1 0	6 0	25
3	Attleborough......	..	11 6 0	5 0	36
3¾	Eccles-road	..	11 11 30	5 30	40·90
3⅛	Harling-road......	..	11 16 0	4 30	41·33

Distance from Station to Station.	——	Time of arrival.	Time of Departure.	Time occupied running.	Speed between Stations.
Miles.		H. M. S.	H. M. S.	H. M.	
7⅞	Thetford	11 27 30	11 34 30	11 30	41·08 (*c*)
7	Brandon	11 47 30	11 50 30	13 0	32·30 (*d*)
3¾	Lakenheath	..	11 58 30	8 0	28·12
			P.M.		
5¼	Mildenhall........	..	12 7 15	8 45	36·70
7	Ely..............	12 18 45	12 22 0	11 30	36·55 (*e*)
14¾	Cambridge........	12 51 0	1 3 5	29 0	30·51 (*e*)
10	Chesterford	1 25 0	1 26 30	21 55	27·3 (*e*)
4	Audley-end	..	1 37 0	10 30	22·85
6	Elsenham	..	1 48 0	11 0	32·72
5¼	Bishop Stortford ..	1 56 0	2 3 30	8 0	39·37 (*f*)
6	Harlow	..	2 14 30	11 0	32·72
4¼	Roydon	..	2 19 30	5 0	51
3	Broxbourne	..	2 23 30	4 0	45
4¼	Waltham	..	2 29 30	6 0	42·50
3	Ponder's-end......	..	2 34 0	4 30	40
2¼	Water-lane	..	2 37 30	3 30	38·58
1¾	Tottenham	..	2 39 45	2 15	46·66
2	Lea-bridge........	..	2 42 30	2 45	43·63
2	Stratford	2 46 30	2 49 30	4 0	30 (*g*)
1¼	Bow	..	2 53 30	4 0	18·75
2½	London	2 58 30	..	5 0	30
				3 47 40	33·20 (*h*)
				4 28 30	28·15 (*i*)

"But a speed of less than this would be found sufficient for some of the traffic.

"The Cork and Bandon are another Company striving to bring down their working expenses. They, like the Eastern Counties, are experimenting—if matters of fact can be so called—with light engines. They are running light engines on their line, and we understand with success.

"It is only where parties are *obliged* from necessity to economise, and where, too, they have the goodness of head and heart to bestir themselves, that we find working expenses are reduced, or *can* be reduced. The majority, in the receipt of splendid revenues, but who,

"REMARKS.—(*a*) Train consisted of engine, 8-wheel N.W. carriage with tank, 6-wheel first-class carriage, and 4-wheel break van. (*b*) Took water. (*c*) Water. (*d*) Coke and water. (*e*) Water. (*f*) Coke and water. (*g*) Water. (*h*) Actual running. (*i*) Including stoppages.

"Coke consumed, 11½ cwt. = 10·22 lbs. per mile.

nevertheless, pay small dividends, say, 'Pooh! its all nonsense; these are our expenses, and we cannot do the work for less.' We, however, have a very strong impression, that in nine cases out of ten they can most materially reduce their expenses, and yet be even more liberal in their little necessary or useful expenses. In a word, by looking (with the view of thinking and acting) to the cost of trains as the primary object, and other large expenses as secondary objects, they may realise larger profits and even work their lines better."

In all new propositions for public benefit a certain amount of existing habits, or existing interests, may happen to be entrenched on. In the case of the large carriages, certain vested interests are affected; it would seem, by an article in the 'Railway Times,' devoted to the consideration of this subject, in which the editor analyzes the question of economy to the company on the true principle of first cost and wear and tear, proposing what we think very fair, that the prices ought to vary in proportion to the cost per passenger, divided on the capital employed, and the space occupied.

"These composite carriages of the North Kent line are formed of two four-wheel carriages bolted together, and are capable of separation when required, so as not to be unwieldy in case of removal, but constituting a rigid carriage when on the line. Their breadth is 9 feet and their length 40 feet, giving a total floor area of 360 square feet, or, as builders would say, upwards of three squares and a half.

"The advantages to the public of this mode of construction are, first, the possibility of using thoroughly flexible springs, with the utmost steadiness and freedom from oscillation, precisely as a long steamer preserves an even keel, while a short one pitches; secondly, greater safety, for, in case of collision, the long carriages will not leave the rail to ride on each other's backs, in which case the compressed buffers are discharged like cannon balls, breaking passengers' legs beneath the seats, as has more than once occurred in collisions; thirdly, eight wheels to one carriage are safer than four.

"The advantages to the shareholders are as follows:—

"First. These composite carriages cost the companies *only one-half* the price per passenger that the common stock costs. Secondly. The dead weight per passenger is *only one-half* that of the ordinary stock. Thirdly. The number of wheels are *eight* instead of *sixteen*.

"For these reasons, *cæteris paribus*, the engine power required ought to be considerably less, and the wear and tear of the road ought to be considerably reduced.

"The next question is of accommodation to passengers, misrepresented by 'Delta.'

"The carriage is divided into four apartments, each having 90 feet of floor area. Externally they are all alike, being all fitted with plate-glass windows of larger size than any other carriages on any

line, giving full view of the country. One of these apartments is furnished or trimmed with cloth and blinds, cushions, &c., and is arranged for twenty passengers seated. Now to compare this with an ordinary first-class carriage.

"The usual length is 16 feet 6 inches, the breadth 6 feet, and a proportion of the cubic contents is taken off by partitions, so that we may estimate this area in round numbers, say at 100 square feet: but the height is only about 5 feet 3 inches, making up 525 cubic feet; but the height of the long composites is upwards of 6 feet 6 inches, making up a total of 585 cubic feet, giving the same cubic measurement to each first-class passenger.

"The three second-class apartments are unfurnished; but as in all other particulars they are like the first, there is the manifest advantage of converting them to first-class when required; in fact, with a little arrangement, the furniture might be made moveable to suit particular localities or seasons.

"Each of the second-class apartments is fitted for 32 passengers,—the precise number occupying a whole second-class of the ordinary stock, and with about the same cubic contents.

"Thus, these long carriages, by reason of their extra width and length, are capable of accommodating 116 passengers in a length of 40 feet of train, or 44 feet including buffers, moving with perfect steadiness, without the need of screw couplings to bind the train together.

"To carry the same number in the ordinary stock would require four carriages, measuring 84 feet in length. But we will state it yet more clearly:—

"Four long composites will convey 384 second-class and 80 first-class passengers, total 464, on 32 wheels, the length of train being 176 feet, and the number of doors 32.

"Twelve second-class and four first-class ordinary stock will convey 384 second-class and 72 first-class passengers, total 456, on 64 wheels, the length of train being 336 feet, and the number of doors 120.

"The mere extra length of platform, and extra number of servants required to open and close doors and grease wheels, is an important item in the daily work of a line of much traffic.

"We have made the comparison with the ordinary four-wheeled stocks. But when it is compared with the six-wheel stock used in the Eastern Counties, North Staffordshire, Blackwall, and other lines, it will make a difference approaching towards a dividend.

"Thus, the savings of the new stock are:—

Wheels	32	:	64
Doors	32	:	120
Platforms	176	:	336
Dead weight	50	:	100
Servants	50	:	100

This is exclusive of saving in traction and maintenance of way, which should be in the same proportion, if all things be rightly managed.

"Having given our statistics in a form sufficiently impressive to shareholders, we now return to the especial criticism of 'Delta's' letter.

"He expresses an opinion that 'all persons who can afford it should ride in first-class carriages,' in order to foster the 'comfort of the poor.'

"This is very vague. It is simply begging the question of what a man may choose to expend his income in. Thus a man may choose to travel second-class, and spend the savings in a better dinner, or he may travel second-class with his family instead of first-class by himself, or he may choose to pay for another day's country air out of the savings. But, apart from all this, we suspect that, with the exception of a very few lines, the first-class passengers are those the Company gain least by.

* * * * * * *

"But he gravely proposes a war on the company, by riding in second and third class, till he has driven the economical carriages off the line.

"'1. The period for renewing annual tickets is at hand. The fact is, that now the second-class carriages are preferable to the first. Let gentlemen decline taking their tickets, and agree to travel together in second or third-class carriages until these miserable vans are removed.'

"We think that if the whole of the first-class passengers would take to the second-class, so as not to need first-class carriages at all, the result would be better for the dividend, unless in cases where the numbers are sufficient for entire first-class trains.

"For example, the first-class in the composite carriages holds twenty, at 3*s.* per head—this would be 60*s.* In second-class, at 2*s.* per head, thirty-two passengers would be 64*s.*

"The following sentence in 'Delta's' letter inclines us to suspect that he may have some interest in the water rivals of the North Kent,—the people who probably originated the nickname, in order to make people 'Come out o' them *wans*:'—

"'2. Let the Gravesend and Woolwich people pause before they cast off their express boats. They have a vast advantage in their position; and, with union, skill, and firmness, they might easily bring the directors to agree to what is reasonable and right.'

"We much doubt whether 'Delta' will succeed in persuading many of his fellow-travellers to join him in this direful act of retribution. Men will more commonly be found to prefer an hour's warmth in a dry railway carriage to at least twice that time upon the sloppy deck of a cold steam-boat.

"But if he be really a first-class, accustomed to his railway armchair, very rich, and a little impatient, preferring the family hotel to

the commercial inn, the post-chaise to the stage-coach, and willing to pay for his ease in the arm-chair, instead of gregariously rubbing shoulders in the saloon, we will point out to him a mode of attaining his end, without depriving others of their cheap accommodation, which would be a most selfish conclusion.

"The most costly carriages are those *two* abreast—the least costly those six abreast,—coupée carriages are yet more costly. Now, there is no doubt that the directors would put on a carriage of all coupées if they could make sure of customers at a paying rate. As the ordinary first-class carriage costs twice the price, and weighs twice the weight of the new carriages, 'Delta' can scarcely object to pay double fare. It is unreasonable that he should have extra accommodation without paying for it. There has been a talk amongst railway people of going to Parliament to increase fares: the policy of this step may be questioned. But to diminish expense is just and right; and we believe it will be found that few persons will pay the extra fares—perhaps even 'Delta' himself will hesitate when the chance is offered him: at all events, were we directors, we would make the trial, by putting on a common first-class carriage at an increased fare. We have often remarked that single passengers will each take a separate compartment, but we doubt if they would be willing to pay for it. 'Delta' himself insists so much on his *annual* ticket, that we are sure he looks to economy also, or he would be for paying daily, or taking a post-chaise, or rolling up in a carriage of his own, whenever railway directors were guilty of lese-reverence."

In further proof of what we have said on the subject of railway traction, we now extract from the proceedings of the Mechanical Engineers' Institution, a portion of a very masterly paper, by Mr. M'Connel, the locomotive superintendent of the North-Western Railway:—

"The first strain to which the axle is subject is that arising from the weight of the waggon and load, which being received or resting on the journal produces the greatest effect upon the axle at the outer face of the wheel-boss, and to which is to be added the momentum of the load in falling through the spaces caused by *inequalities in the joints of the rails.*

"The injurious consequences upon the axle of inequalities of the road surface, and flat places on the surface of the wheel-tyre, by the jolting or perpendicular motion which they produce, cannot be accurately estimated, and these are very much increased when the bearing springs of the waggon or carriage are not sufficiently elastic, and do not yield to the shock or blow downwards, so as (to use the expression) to cushion its effect. As an instance of the imperfect action of the springs, I would allude to those in use on many waggons, in which the form and construction cause them to be so rigid that the downward blow is more like a hammer upon an anvil. To obviate this strain as much as possible, it is necessary to proportion the spring so

as to sustain the load properly, and yet to be of sufficient elasticity to absorb the effect of the load oscillation.

"The strain arising from the oscillation of the waggon on curves from imperfect coupling, and increased by the lateral freedom or space on the bearings or play between the rails and flanges of the wheels; which when an irregularity occurs on the side of the rail, or any sudden cause disturbs the direct motion of the waggon onwards, is in effect the same as a blow upon the flange of the wheel, the radius of the wheel tending to act as a lever to break the axle at the inner face of the boss of the wheel.

"This strain is in the compound ratio of the momentum of the load, the angle at which the wheel strikes the rail, and the distance from the centre of the axle to the point of impact, producing an effective strain upon the axle at the inner face of the wheel-boss, which extends proportionately over the whole axle between the wheels. To lessen in practice as much as possible the deteriorating effect of these descriptions of strains upon the axle, the following conditions are important:—

"That the bearings or journals of the axles fit as closely to the brasses as is consistent with freedom, the allowance of flange-gauge of wheel being quite sufficient for the carriage to move freely round curves and meet any irregularity in the gauge of the rails.

"That the waggons or carriages be as equally loaded as possible, and the draw chains be exactly in the centre; and as side chains are dangerous they should be completely removed, provision being made for a duplicate centre draw-chain should a failure take place. As the damage to the loading of waggons is in proportion to the oscillation, they should all be screwed together by means of screw-couplings, having spring-buffers upon both ends of every waggon.

"It is well known that the injury to the waggon, to the load which it conveys, to the axle which carries it, and to the road over which it runs, is very much aggravated if the waggons are allowed to oscillate from side to side, and become like so many battering rams, injuring themselves and all substances in contact with them. A train of waggons or carriages should be jointed together similar to the vertebræ of an animal, by which means any sudden lateral action would be neutralised by the support derived from the neighbouring vehicles."

This is clear reasoning in favour of the long carriages lately adopted, whose length prevents injurious oscillation, and renders innocuous any unequal loading. Waggons on eight wheels, on thoroughly flexible springs, with free lateral movement on the wheels, would not damage the road or rails; and moreover, they would carry one-third more load, because no spring or wheel could be placed in the position of having thrown on it the momentum of the whole load, as is the case with a four-wheel waggon, in which the springs cannot be flexible, as the oscillation

would become excessive, and moreover, the springs would be broken.

A notion has prevailed amongst superficial people, that a light or small engine cannot be so durable as a heavy one. The fallacy of this notion will easily be apprehended by competent judges, who know that the working parts and surfaces are larger in proportion, while the weight of moving bodies, as pistons, &c., is less. There is no doubt that greater durability will be attained than in the monster machines. The merit of ordering, on his own judgment, the first light engine with a body attached, after experimenting on the 22-cwt. steam carriage of Mr. Samuel, is due, we believe, to Mr. Charles Hutton Gregory, of the Bristol and Exeter line, in whom mechanical talent seems hereditary. It was called the "Fairfield," and was at first not quite successful, on account of the small size of the vertical boiler. This having being exchanged for a sufficiently large horizontal one, the result was thoroughly satisfactory. For the first time 8-inch cylinders ran on the rails of the broad gauge. The Eastern Counties followed next; and then Mr. Nixon, the engineer of the Cork and Bandon, at once adopted the system, and was enabled thereby to work the worst half of a twenty-mile line at a profit, although the unfinished state of the other half obliged the company to work by stage coaches and omnibuses.

Mr. McConnel, in his able pamphlet, speaks of "the momentum of the load in passing through the spaces caused by inequalities in the joints of the rails." The Great Western Railway, with its longitudinal bearers, and the joints secured down on bearing plates, has the best joints in general use; but more new plans have come forth under the pressure of necessity. "How can the shareholders expect dividends," said a railway officer, with considerable *naïveté*, "now that the capital account is closed?" Stimulated by the shortness of funds wherewith to buy new rails and new sleepers, the Eastern Counties Railway Company have tried with success a new plan, to obtain some years' longer wear out of their old rails.

The ends of the rails were hammered down by the rolling of the engines on their top and bottom sides, and the chairs also were hammered, so that no solid fit could be obtained. For this reason the chairs were removed from the joint, and the two rails were bolted together by side cheeks or fishes of cast iron 18 inches in length—which would be better in wrought iron—fitting into the side channels of the rails. Provision was made for expansion and contraction in the bolt-holes, and chairs and sleepers being applied on either side the fishes, a rail of permanent joints, over which the engines and carriages would roll without concus-

sion, was produced. It seems likely that this principle will be universally adopted both for old rails and new ones, as it is economical in saving wear of machinery, and expenditure of coke. And moreover, in laying down a new line the expense ought not to be greater than in the ordinary plan, for as much less iron should be rolled into the rails as would make the fishes and bolts. At present the strength is unequal over the different portions, and causes blows. A generally lighter rail thus rendered equal by fishing, would at the same work last longer than a heavy one.

In addition to this plan a new mode of applying longitudinal sleepers in connection with the double T rail, has been laid down on sample. On each side of each rail, there is applied a piece of fir-timber seven inches square; grooves are cut in which to insert the rails, and the two timbers being bolted together, the rail is held between them as in a continuous wooden vice. Ten months' wear of the hardest-worked line in England has produced no sensible yielding in this arrangement, and the rail being bedded in timber to its upper-lip is not injured by side lurches of the engine. It is all very easy to take out and replace, and it has none of the difficulties experienced in the longitudinal bearers with the rails bolted thereon, as usual in the broad gauge lines.

Nor is this kind of railway more expensive, for we understand that, supposing the land and levels provided, a single line of narrow gauge with light rolling stock sufficient to carry 2,000 passengers 100 miles per day each, can be supplied at present prices of materials for less than £3,000 per mile, and thus would be a really *permanent* way for twenty years, with scarcely any repairs.

On the same principle as that described, Mr. Barlow, the engineer of the South-Eastern, has laid down rails without any timber whatever. At the joints of the rails he uses two very *long* half-chairs of cast-iron with broad feet beneath them. These half-chairs are bolted together laterally, and clip the two abutting rails between them like the jaws of a vice. Other cast-iron chairs of a similar kind are applied at the mid portions of the rail, and the gauge is preserved by cross-ties of cast-iron. The whole lies upon the ballast without the intervention of timber. Too little time has intervened as yet, to pronounce how far this system without elasticity, can be applied to the transit of heavy rolling stock. Of one thing we are sure, that if directors wish to economise, to have really practical knowledge, they must experiment, and glean the knowledge of the useful by many failures in the useless. And if it be found practicable to construct a really rigid road on the plan of Mr. Barlow, without elasticity, we foresee that it will lead to immense improvements in engines

and carrying stock; and amongst them will not be forgotten the necessity of using such a system of brakes as will not destroy the circular form of the wheels, converting them into revolving hammers while running, and the worst possible form of sledge while gliding.

Glancing over the railway map, we find certain spots of England in which the diverging lines of railway intersect each other like an intricate network. On the eastern coast, in the neighbourhood of Newcastle, there is one of these railway ganglions. They are the coal and mineral lines, the original plants from which suckers innumerable have spread all over Engand. There were the wooden rails first laid to fill up the ruts worn in the tracks; there were the strakes of iron first nailed on to fill up the ruts in the wood. Then succeeded the cast-iron trams, and the short piles and cross-sleepers. Then grew up in turn the wrought-iron rails, on which the fire-horse was harnessed to the trains of "black diamonds"—the uncrystallized carbon. Then grew and flourished the lords of coal and iron, the Blenkinsops, and Crawshays, and Hawks, and Nicholas Woods, and Stephensons; and amongst the category stands forth a lord of Ravensworth, famous in history as the treasure-holder who helped George Stephenson "to build his first locomotive."

Why, reader, were these roads made, think you? Not for vain-glory, not for any purpose akin to the building of Euston-station. They were made because they were the cheapest and most economic of all roads. They served better than any other kind of road to carry the produce of the under-land to the seaports, there to distribute it far and wide.

There is a very large class of people called road excavators, or people who make roads, raise valleys and level hills, for the formation of highways and railways,—a race that has grown up out of the navigators or "Navvies" who constructed the canals for inland navigation. The *tools* of these people, are amongst others, iron rails and wagons to run thereon. It is a simple fact, that to make a highway cheaply, requires a moveable railway. The object to be achieved is to transport heavy and bulky matter at the lowest possible cost. Yet it does not strike the makers of highways, or rather the employers of highway-makers, that it would be any advantage to transport other things than earth and stones in the same mode on rails. One difficulty has been in the way—the want of a general consolidation of road trusts. When this shall take place, we may expect that many of the highways will have rails laid down on them for horse transit, and capable of connecting with the various lines of railway; and in such case property along their borders will take an additional value. Not

long after, improvements of level would gradually take place, and light locomotives would be introduced. Every ancient inn, and every old town would then be restored to its original value, with a constant prospective increase. And then only will there be such a salutary control exercised over the general railways, that their proprietors will be forced to tread in the track of their own interest, and foster their traffic on free-trade principles. Then will they be glad to attach house-dwellers, and factory-owners, and farms to their borders, by binding arrangements of good faith, guaranteeing them against unjust tampering with existing fares, or capricious alteration of trains. Then will they find it their interest to encourage far more frequent trains, and if needed, to increase the number of their rails, if not throughout, yet at intervals, for the increase of stopping stations. We are satisfied that, ultimately, the most profitable lines will be those of short traffic, and the long through-lines must, as in the olden time of horse-coaches, prove the least profitable.

It is only by such a system that agriculture can be lifted out of the slough of despond, and raised to the scale of a mechanical science and manufacture, from its present condition of miserable handicraftry. The business of miners and quarrymen is, to transport heavy materials over the earth's surface; and what else is the business of the farmer? Manure on to his land, sand on to clay, and clay on to sand; wheat, barley, oats, rye, turnips, cabbages, peas, beans, cattle, and sheep, or the meat thereof, to transport from the farm to the town or city. Is not this the be-all and end-all of farming? And if rails be the cheapest road for the miner and quarryman, as long practice has determined, even in the districts where stone is plentiful, how should it be otherwise with the farmer?

The present railways have yet served but little purpose in agriculture. For long distances they have been used, but for under twenty miles they are comparatively useless. If a farmer has to load his carts, and team them two miles to a railway station, then unload them into the railway wagons, then reload into other carts and team them a mile to the market, it will be cheaper for him to save unloading, and use the highway altogether, to the abandonment of the rail. But if, by any arrangement, the highway can be run direct into the farmyard, as a siding runs into the colliery, the farmer might at once get rid of the greater portion of his teams, and realise a profit out of his savings, even at his present high rents.

"A railway on to a farm!" cry out both farmer and landlord, out of breath. "Where, in the name of dungheaps and Georgics is the capital to come from?" Our simple answer to this is—

Consols are at £95, and will probably rise to £100. Let a profitable investment be shown, and capital will flow to it by its mere gravitation.

But farmer and landlord have a notion of a railway, as something that varies from £20,000 to £50,000 per mile. We have a different view of it. We have no doubt, that for farm purposes, for horse-teams, and even for light engines, a single line of rails may be laid down on level surfaces, like Lincolnshire or Cambridgeshire, or the Norfolk Moor, for a sum varying from £400 to £500 per mile, and that such a railway might be made portable, to vary its direction. In fact, we have seen the principle set forth practically. If we mistake not, the Southend pier, on the northern bank of the Thames below Gravesend, is provided with a light rail and light wagons, for the transit of passengers and goods, whereon a pony draws about sixty persons, and which costs, wagons inclusive, somewhere about £600 per mile. We are quite sure, that in Lincolnshire and Cambridgeshire, no farm occupation road would be made on the macadamised principle at anything like so cheap a rate. We are sure, that were any landlord to lay out his acres afresh, so as to make them the most eligible to his tenants, he could adopt no plan so profitable as a railroad, with the farms located on each side of it. We believe that Earl Ducie has laid out a model farm in the neighbourhood of Shrewsbury, with rails communicating throughout the fields; but we are not aware that he communicates with any railway, and therefore the experiment has no fair chance.

It is only by the railways running into the farms that a really good result can be obtained, and farms be brought up to the standard of manufactories. In the Lothians of Scotland, most farms have a steam-engine fixed to do farm drudgery, such as thrashing and preparing food for cattle, cutting chaff, &c. But all the coal to feed the steam-engine has to be carted on to the farm. Now cheap coal is one of the first requisites of economic farming—of systematic steam-labour.

At present, portable steam-engines on wheels are drawn by horses, over bad roads, to farmyards, where thrashing is required. With a railway, the steam-engine would propel itself, and draw its fuel behind it. When in the farmyard, the wheels being blocked or raised, it would become a stationary engine. Again, it might be made available in the labours of the field; not to plough—for the plough is but a rude tool, suited to the peculiar action of horses—but it might be made to move a roller-harrow, that would break up a long run of ground far more effectually than the plough. With a moveable system of rails, easily adjusted, all this might be brought to bear; and a system

might be introduced of injecting the ground with steam and gaseous manures, going directly to the roots or feet of the plants, and prolonging growth during a much longer season than usual, —even producing vegetables in the winter time. The same steam-engine, with a few machine tools, would enable the farmer to construct his fences and gates cheaply; and a large variety of new uses would grow up—even mills and improved granaries.

To do all this of course requires a remodelling of the farm system; for never can the farmers realize cheapness of production till they are "on the rail," and never can the rail thoroughly prosper till the great majority of the community, those connected directly or indirectly with land owners, shall regard it as their legitimate road. In Ireland, from this source must spring the large prosperity of the Midland Great Western and other lines. A rail without farms on it is like a river without landing-places—a street without houses—a canal without a towing-path —a crane without chain or tackle—a ship without masts—a steamboat without an engine—an engine without a boiler—a newspaper without a printing-press—a spinning-mill without cotton or flax.

To conclude. Rails have been laid down on farms. Steam engines have been erected on farms, and many attempts have been made to plough by steam;—but no rail has yet been laid down leading to the farm. Only by the interests of the borderers on railways being united with those of the railway owners, can railways prosper; and a large portion of their difficulties arise from the belief that their customers are a race of people indefinitely squeezable in purse, while the customers regard the railway owners as a mere crew of extortioners, gaining cent. per cent. by their transactions. Yet borderers will do well to bear in mind the fact, that upon the true uses of the railway must be based the only true PROTECTION TO AGRICULTURE.

It is quite certain that the government of railways is anything but satisfactory hitherto, and that where the mode of rule has been advantageous to shareholders, it has been a result of individual character in directors, and not an institutional consequence. Nationally, we do not care for this, because we regard railways as a transition state of intercommunication, which will ultimately make land more valuable, just as houses and streets constitute each others' value, each being comparatively valueless without the other. But let shareholders who regard railways as their private property, seriously ask themselves the question, why directors burden themselves with an office of responsibility, and of occasional great odium, ostensibly for the benefit of the shareholders, and very commonly holding themselves but a very small stake?

To some directors holding a seat at several boards, the £100 a-year from each may be a consideration; but assuredly, none of the railways will obtain any profit from their services. But when a man of large private business, whose time is precious to him, and who holds scarce any shares, attends duly in his place at the board meetings—to what motive are we to attribute it? Is it private benevolence, or public spirit? Or is it self-interest, direct or indirect? Self-interest! asks a distant living clergyman, or country practitioner, or ancient spinster, what self-interest can a man with a business producing him ten thousand a-year, have in sitting at a board for £100? Why, that he may provide for his poor relations, by dividing the appointments with his brother directors, as has been the rule in more than one railway compact—without any regard to fitness. And he may take his proportion, also, of profitable contracts. "No, no," says the shareholder, "the law forbids a director to be a contractor for his own line!" Green! sprouting with verdure! art thou, oh! shareholder. When the Scottish edict forbade householders from sweeping their chimneys with a live goose pulled by a rope, one canny gudeman "thocht twa ducks would do just as weel." Of kin to him was the cousin "sax-and-thretty times removit," who when taking a "respaccable position as gentleman to a gentleman," delicately insisted that he would "serve for puir luve, and for the sma' matter—the pennie-fee—he wud aye rather be contentit wi' just the wee things he could pick up aboot the hoose." What is to stop a director of the right river-bank, from giving a contract to a director friend of the left-river bank, and *vice versâ*. What to a friend, or brother, or cousin? Both lines go to Versailles.

And let not shareholders complain. They themselves are in fault. They wish to enjoy a large per centage without labour, and without paying their servants. This is an injustice. There are but two modes of action. Either to make directors of very large shareholders of fair intellect, who have an interest in preventing peculation, or to pay the business directors in such a mode that their gains may be commensurate with the increasing profit arising from their exertions, that they may have more interest in good management than in bad. It is quite a clear case that those who work ought to have a larger share than those who are idle—the directors than the shareholders. For our parts, though we see great objection to directors taking contracts indirectly, we see none to the direct mode. Why should they be debarred from the profit which would go to a stranger, if that profit be fairly and honourably earned, if the rules and regulations be rightly framed? The objectors may perhaps say that

there would be unfairness. We do not think this by any means certain. The smuggler who gains indirectly, needs a larger per centage than the open trader, in order to compensate for risks. All the world knows that manufacturers, and contractors, and bankers work for profit, and that they will not work without profit. Nor ought they.

"Open contract! public tender! no favour! public competition!" cry out the uninitiated financiers, the men imbued with the fallacy that two and two always make four. Alas, for these good people! who know not, that if a really snug job is to be perpetrated, there is no form so safe as that of advertised tenders. The public mouth is stopped, and unlucky people are what is called "cushioned." Government advertise for all their supplies by competition, but notwithstanding, in some cases the supplies are hereditary in families. And, in truth, we would not advise a contractor to get a hold of a contract against the will of his paymasters or their *employées*. Chancery-suits are awkward affairs, the worst part of them being the waste of time and energy they cause to him who fain would work whether he gets paid or not. But there is also the other side of the question. The contractor may be a shrewd speculator, who gives his contract to his shrewd lawyer, to ascertain, before he signs it, that there is nothing stringent against him that can be legally maintained, and that, on the other hand, he has the company legally fast. And then away he goes to work, to keep the word of promise to the letter, and break it in the spirit. This is bad enough in the case of earthwork and brick bridges, but what can be the result in the case of mechanism?—a mere matter of opinion, scarcely to be defined by speech. All the world knows that "Whitworth's screwing tackle" is universally specified by railway engineers for their workshops. Other mechanics doubtless can make as good, but the articles are never put up to competition, because prices would be offered by some that would only yield a profit by inferior workmanship. Engines, carrying stock, and machinery generally, fall into this same category; and we have no doubt that, with scarce any exception, take the whole railways over, the lowest priced will be found to have been the most expensive to the companies. To sell metal and timber together is the object of the general contractor—on the large scale. The earnest work of the engineer desirous of maintaining a good name by a "good job," is not in the category of such men. And who is to inspect? Who *can* inspect that which, in many cases, can only be tested by working, and with all railway mechanism so retrograde, that no practical machine yet exists for measuring the resistance of trains. Head over ears have the railways been

made—to sell. Head over ears, has the "sledging stock," misnamed the "rolling stock," been thrown upon the lines; and the elementary questions of wheels, axles, bearings, springs, and breaks, saying nothing of the question of engines, are all yet mooted points amongst those whose business it is to decide. The very alpha of the question is not settled, and the omega is yet afar off.

Experimenters tell us that a square inch of wrought iron begins to crush under eleven tons of standing insistent weight; yet every day are engines, with twelve tons borne on the point-like contact of the driving-wheels, traversing the rails at fifty and sixty miles per hour. If the rail be elastic and gets away from the crush, steam power only is wasted; but if the rail be as a solid girder, it rolls and squeezes out. That is one reason why unyielding stone block sleepers have been cast out of the railway category.

Carriers and manufacturers do not put up their implements to unlimited competition, because they cannot afford to use bad machinery. And to this condition must railways come also. And we think that a director tendering for his own line would take care not to have bad stock looking him in the face. And if the shareholders paid apparently more money for it in the beginning, they would pay less in the end. The thing is a matter of demonstration. Inferior stock gets out of order, and an excess of ten, twenty, thirty, or forty per cent., is requisite to keep the numbers going. Ten engines at £2,000 each, cost less, even at the outset, than twelve at £1,800. The item for which credit is taken by so many companies as capital, under the name of rolling stock, is well understood by those in the secret, to be a matter of "opinion." Mr. Harrison, of the Newcastle and Berwick, opines that railway wagons will last twenty years, estimating their depreciation at five per cent. Happy shareholders! if the "permanent" wagons be not permanent after the fashion of "permanent way," the chief permanence being the permanent expense. Captain Huish, of the North-Western, values his second-hand first-class carriages at £330 each, and a builder's profit in addition. Mr. Laing, on the Brighton, says he can build new first-class carriages for £250 each. Verily there is margin here. And railway men assume that the wagons of 1849 will be the patterns of 1869, in a world whose changes are incessant. To our view, railway rolling stock is a portion of incessant transition, much of it resembling, in its commercial value, the old-fashioned carriages, with curvilinear springs, used formerly with a driver and two footmen, but which most modern men eschew as too heavy and costly. Taken in

valuation, ask the East Anglian or the Newmarket what it is worth to sell. Some of the "stock" accounts are really ludicrous as a Limena girl's dowry—

> Unos muebles immovibles.
> Sundry moveables immoveable.

Bedsteads of four posts and canopy, tables hewn from the tree, Pizarro's jack-boots, embroidered hoop petticoats, dozens of ancient satin shoes, the first *caleza*—cabriolet—imported from Spain, some saddles, bridles, and harness with silver mountings, sundry *escopetas, trabucos,* and *espadas,* musquets, blunderbusses, and swords—a few pairs of silk stockings, &c. &c., all valued at the original cost at the time of the Conquest, when a pair of boots at 300 dollars was considered moderate—all these items make up the 20,000 dollars *cabal*—complete.

In the olden time, ere railways yet were, the Chaplins, and Hornes, and Lacys, and Mountains, used practical dynamometers for their stage-coaches—the "osses." "Can't drive that coach, master, she doesn't *follow!*" called out Jehu, with a knowing touch of the hat. "Why, she *weighs* 25 lbs. less than the last!" "Don't care for that, master, she *draws* 100 lbs. heavier. My osses will break their wind at it."

On the rail the locomotive does not break its wind, and if it will not draw the load, a larger locomotive is put on, till the giant machines lose their foothold, and break the crust of the road. No mechanical dynamometer has been substituted for the animal test, and with the exception of a few experiments with select machines and vehicles, the resistance to traction in daily practice is an unknown quantity. Till this be altered, there will be no competition for mechanical excellence to attain the minimum of resistance to traction. The mechanist who seeks to minimise weight and resistance, and maximise power, is scoffed by the majority who wish to sell "wood and iron" in the largest possible quantities. We have heard of an instance in which it was gravely objected, that the wagons of one line were not so valuable as those of the neighbour line, being only three tons tare, while the others were five tons, the load to be borne being equal.

> "Oh, heavy lightness, serious vanity!"

In this question of resistance is involved the question of *dividends,* and a friend suggests that it is well to adopt some rhyming record of this, as the arithmetic books settle the days of the months. Thus, then—